PRELIMINARY INVESTIGATION INTO THE USEFULNESS OF TATTOOS FOR IDENTIFICATION PURPOSES

By

Larysa Nicole Grenier

Submitted in partial fulfillment of the course

FORS 4095 EL

Department of Forensic Science

Laurentian University

Sudbury, Ontario

P3E 2C6

Preliminary Investigation into the Usefulness of Tattoos for Identification Purposes

ABSTRACT: Tattoos are common distinguishing features of many people in today's populations, however, investigation into their usefulness in a forensic context is only just up-and-coming. This study uses four ink colours common in tattoos and the Northeastern Ontario fall and winter climates to see how study tattoo composition in skin is when presented in a harsh environment. Ten samples of tattooed pork (*Sus scrofa*) shoulder with skin attached were left out in the environment for 141 days. Upon collection, eye-visual analysis as well as technological analysis via photographs were done on the colours to determine change. Visually changes were not noted in most samples but, using CMYK and classified Pantone® colours, slight differences were noted. This study shows the preservative properties of a Northeastern Ontario winter and raises areas of future study for the usefulness of tattoos as an identification tool in forensic casework.

KEYWORDS: forensic science, decomposition, tattoo, ink, identification, Northeastern Ontario

ACKNOWLEDGMENTS

Thanks would like to be given first and foremost to Dr. Scott Fairgrieve, supervisor for this project for allowing a fairly unexplored topic be looked at with the gracious host of Laurentian University Department of Forensic Science. Thanks would also like to be given to Dr. Gerard Courtin for advice of tackling endeavour of placing and monitoring samples in the environment. Forensic entomologist, Tracy Oost, was a great help in the managing of the samples and preparation for putting everything together, so my great thanks go out to her and all she has done. Great thanks to tattoo artist and classmate Janaye Tucker and her shop Pricked Tattoos in Lively, Ontario, Canada who made finding a professional who would be okay with doing this a lot easier. Finally, my parents, especially my father Rick Grenier, need thanks and acknowledgment for supporting me, and giving a little man power when needed to collect samples in the heart of a Northern Ontario winter. Thank you to all who have helped this project on it’s journey.

TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURE

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction and Importance

One of the most pivotal questions to answer in a death investigation is who has died? To do this, investigators look at the human remains and examine it to find characteristics that may be classified as primary or secondary. Primary characteristics are identifiers such as DNA evidence or fingerprints that are unique to an individual. Secondary characteristics are possible or presumptive identifiers such as birthmarks, scarring, or tattoos (Starkie et al. 2011). It is estimated that 10-16% of adolescents in Western countries have tattoos and 3-9% of the general population (Byard 2013). This makes tattoos a potentially significant identifier and may be useful for the identification of remains in forensic cases. Not only are the designs an identifier for known missing persons, but they can sometimes provide information such as occupation, club/gang affiliation, military service, names of family, medical conditions, prison history, and religious or cultural affiliations (Byard 2013).

1.2 Background Information and Current Literature

Tattoos are designs made from ink deposits in the epidermal and superficial dermal layers of the skin. They remain permanently in the superficial dermis layers (Haglund & Sperry 1993). The average depth of a tattoo is approximately 0.6-2.2mm in the top half or third of the dermis (Clarkson & Birch 2013). Amateur tattoos can be crudely done and deposit the ink with much more variability than professional tattoos. As with other secondary characteristics, tattoos can be distorted or concealed in numerous ways making viewing of the design difficult. This becomes even more challenging in decaying tissue, when hydrogen sulfide creates dark spots on the skin concealing the design. Previous methods of visualization suggest applying a 3% hydrogen peroxide solution to lighten the skin (Starkie et al. 2011). This however, is an invasive method that tampers with the skin of the deceased and does not help in the reimagining of potentially “covered up” tattoos. Cover up tattoos are tattoos done over top of a primary tattoo and this can be done simply to change the design or to hide a known identifying tattoo, such as one obtained during time in prison. It is in these instances that an alternate light source is used in re-imaging or enhancing the tattoo.

Ultraviolet (UV) imaging, at wavelengths of 10-400nm, is useful for detecting surface alterations, structure, and melanin content. Infrared (IR) imaging, at wavelengths of 700nm-1mm, is used to view superficial layers of the epidermis and deeper skin structures (Starkie et al. 2011). These types of alternate light sources are useful in re-imaging tattoos as it has been demonstrated that different inks have different UV and IR absorption properties (Oliver & Leone 2012). UV light is useful in re-imaging tattoos within dark spots, but IR light is far more versatile in its use. IR penetrates deeper into the skin, therefore, it can be used to see if a tattoo has been covered up or if there is latent residue ink from laser removal (Bryson, Wright & Barker 2013, Clarkson & Birch 2013).

1.3 Goals of Study

This goal of this study to explore the effectiveness of using readily available technology such as Adobe Photoshop® and possibly UV and IR alternate light sources to re-image tattoos found on mammalian skin after being subject to short term environmental exposure consistent with forensic casework in Northeastern Ontario.

CHAPTER 2

MATERIALS AND METHODS

2.1 Materials Used

In place of human skin, ten pork (*Sus scrofa*) shoulders with skin attacked were used as the canvas for the ink. For this experiment four colours of ink were used; Silverback Ink brand Stupid Black, Fusion Ink brand Really Red, Fusion Ink brand Royal Blue, and Fusion Ink brand Golden Yellow. To the red, blue, and yellow inks, one to two drops of Silverback Ink brand Clear was also added to enhance the colour and better distribute the pigment in the water base of the inks. Two types of needles were used for the tattooing process; Hydra Needles brand Bugpin Magnum X Long Taper 13 needles for broad detail, and Hydra Needles brand Bugpin Round Liners 11 for fine detail. The machine used as the power supply was the Eikon EMS 420 Power Supply. Once samples were inked, they were placed in cages made of wire and wood to deter any scavenging while out in the environment.

2.2 Method Used

All equipment used in the tattooing process was sterile and new, this was to replicate the process that would be done on a human. Circles, with an average diameter of about 2.5cm, of each colour of ink were made using the 13 needle shader for broad detail. Once this was done, the name of each colour was inked under their respective circles in their respective colours with the 11 needle liner to show fine detail. Since this study was looking at how well the ink keeps in the deeper layer of the epidermis, no heal time was required, nor could occur, with the specimens. After the inking of the samples was completed, the samples were frozen for ease of keep, thawed, then placed out in the environment on October 25th, 2016. Out of the ten samples, six were left to sit on the ground surface, two samples were taken to a marshy area nearby and submerged in water, and two were also buried. Daily high and low temperatures were monitored through thermometers placed near the samples and supplementary information from the local weather station. The samples were out in the environments for 141 days, subjected to multiple types of precipitation and amounts of sunlight, before they were finally collected on March 15th, 2017.

2.3 Analysis

Temperature data collected were analyzed and categorized into monthly averages as the data itself is to judge the amount of decay to be expected from the samples. Colour analysis on the samples were done through photography of the samples. Analysis for CMYK values for each colour of ink from the photographs was done and the values were converted to the closest classified Pantone® colour for ease of identification and differentiation between shades. Personal eye-visual analysis was also done with differences noted in chapter 4.

CHAPTER 3

RESULTS

3.1 Temperature Results

Daily high and low temperatures for the Sudbury, Ontario, Canada area were collected from Environment Canada and averaged on a monthly basis to best represent the temperature climate that the specimens were subjugated to. This is shown in Figure 3.1.

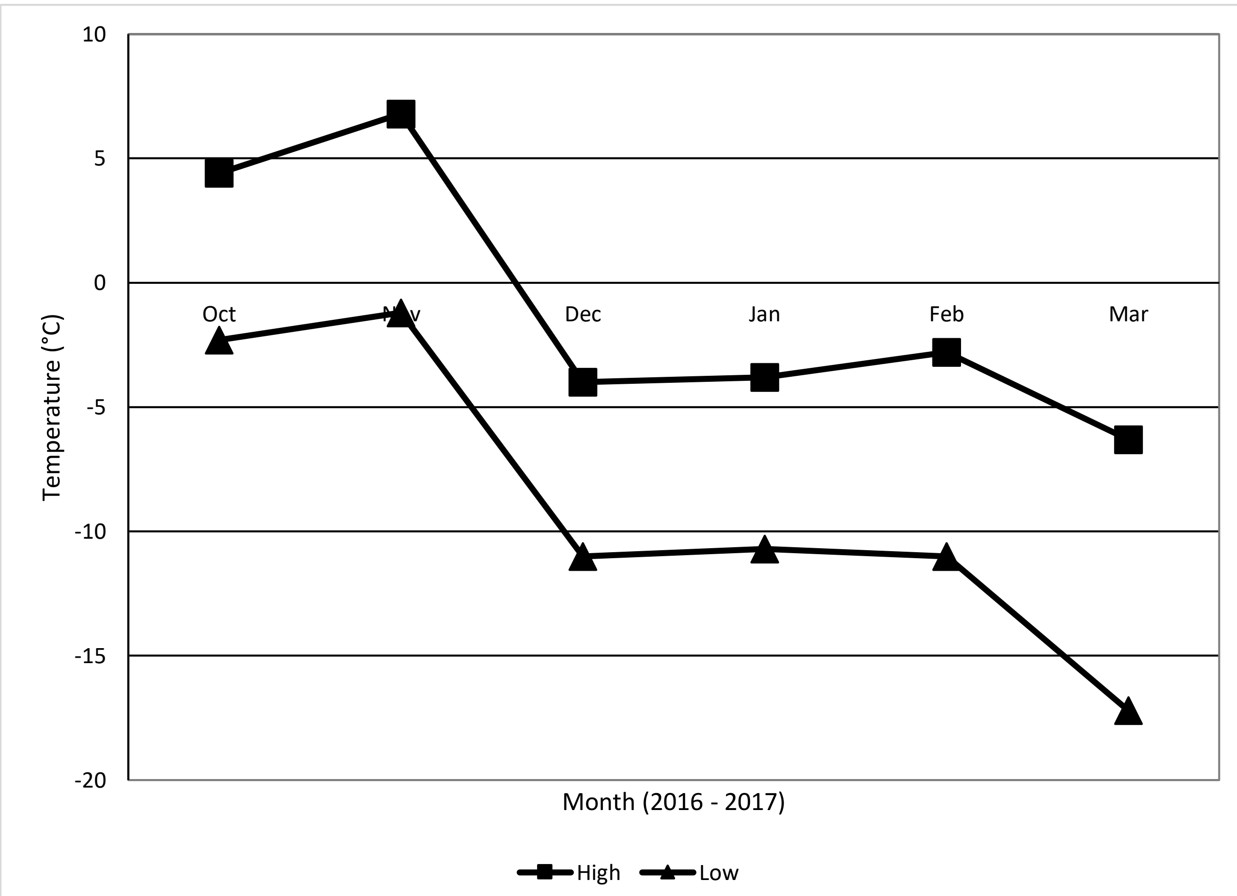

Figure 3.1. Average daily high and low temperature (°C) by month for Sudbury, Ontario, Canada from 25/10/2016 – 14/03/2017 from Environment Canada.

In Figure 3.2, the average daily temperature range is shown to show the consistency of the temperature climate that the specimens were in.

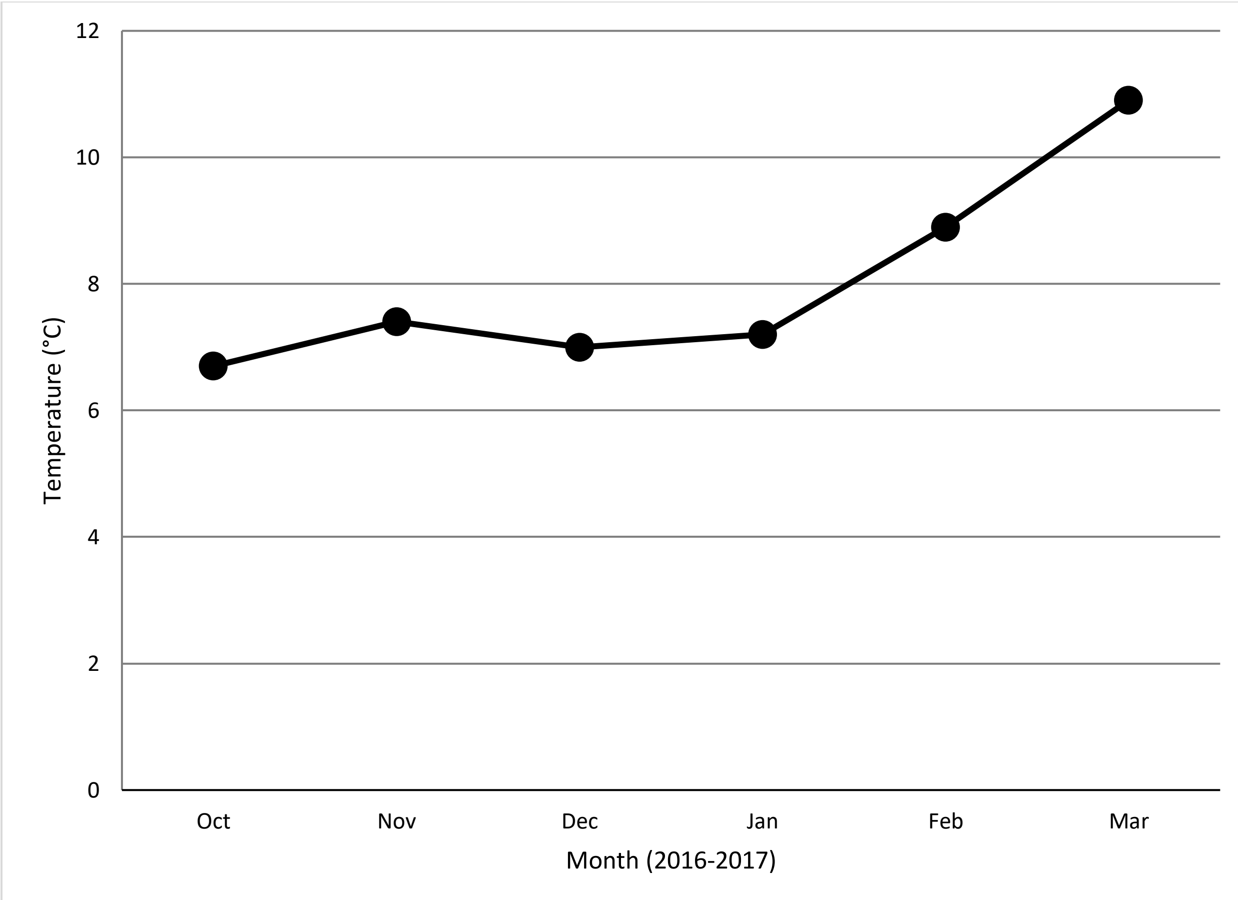

Figure 3.2. Average temperature range (°C) by month for Sudbury, Ontario, Canada from 25/10/2016 – 14/03/2017 from Environment Canada.

3.2 Colour Results

Photographs of the samples were taken before the samples were placed in the environment and taken as well after they were retrieved. Samples 1, 2, and 5-10 were able to be retrieved, while samples 3 and 4 were irretrievable due to environmental conditions at the time. Figures 3.3 and 3.4 are before and after photographs of sample #5, a ground surface sample, that show minimal eye-visual differences in the four inks.

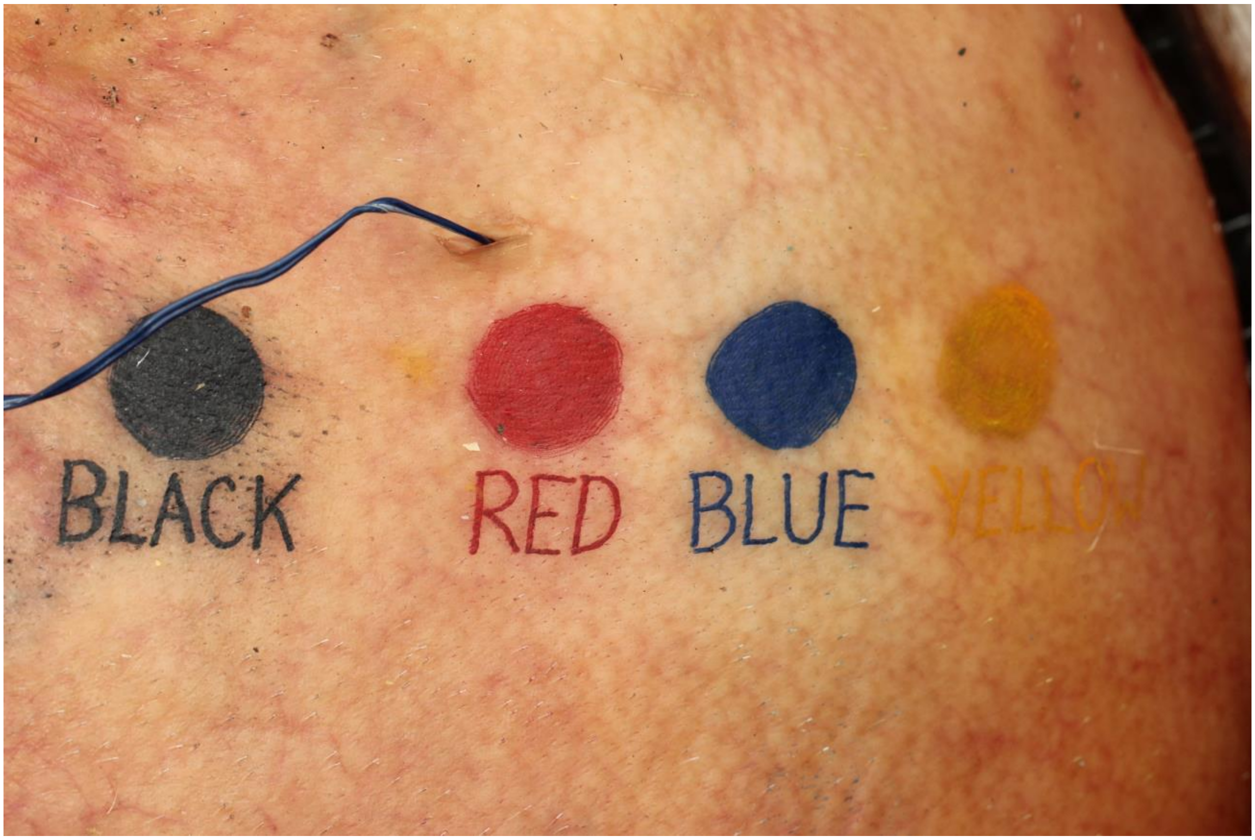

Figure 3.3. Initial photograph of ink circles on sample #5.

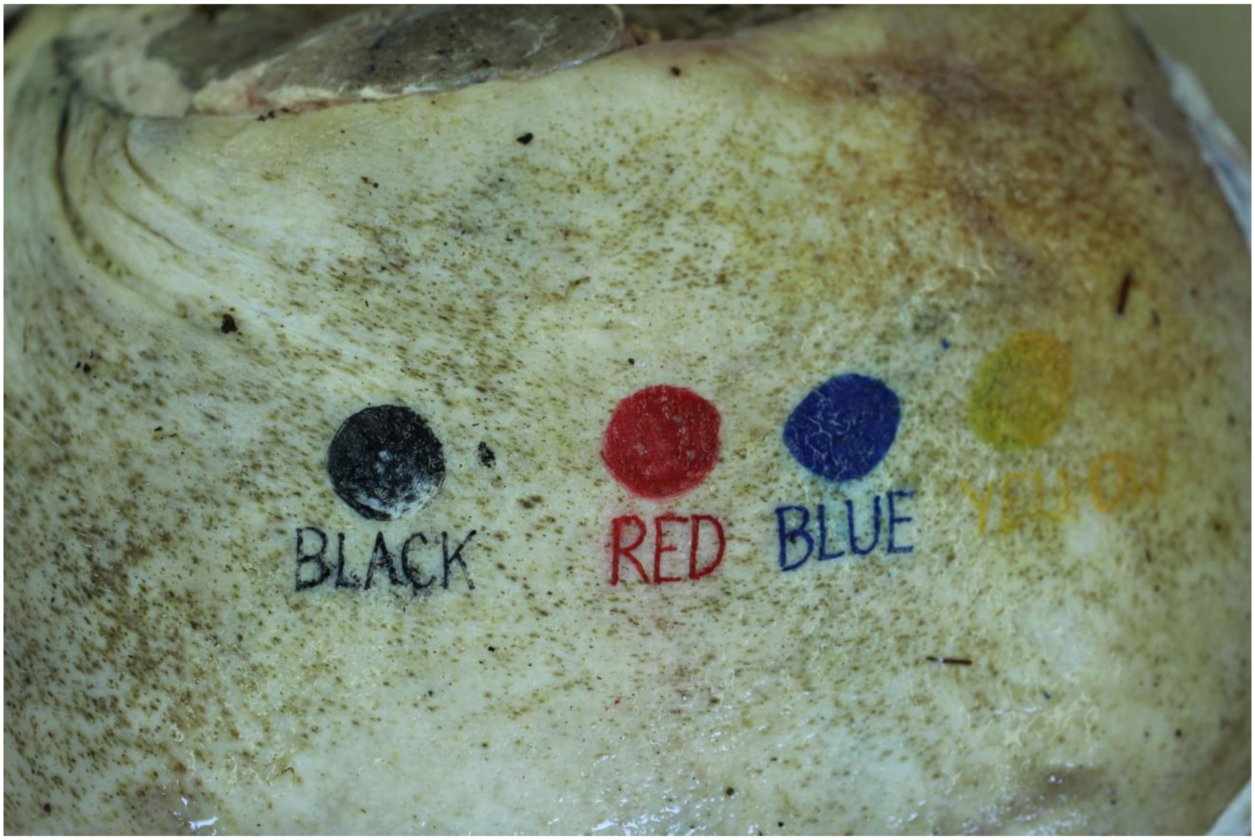

Figure 3.4. End photograph of ink circles on sample #5 after 141 of ground surface environmental weathering.

Cyan, Magenta, Yellow, and Key (CMYK) saturation levels were picked for each colour from the photographs taken using Adobe Photoshop® and converted to the closest classified Pantone® colour for consistency. Table 3.1 is an example of the tables that were made for all specimens collected. Tables for all specimen are available in Appendix I.

Table 3.1. CMYK values before and after samples placement, and closest Pantone® match.

5 - Surface	Black	Before	0	12	14	83	Black 7
		After	21	6	0	82	432
	Red	Before	0	70	70	31	4705
		After	0	73	70	52	4705
	Blue	Before	51	39	0	65	7448
		After	81	65	0	69	5255
	Yellow	Before	0	49	96	25	7511
		After	0	6	70	52	5835

The table shows that black ink increases in cyan tones noticeably. Red ink shows a darkening of the colour overall. Blue ink shows a saturation of the original cyan tones mostly but also a darkening of the colour. Yellow shows a significant change through cyan and magenta tones.

Figures 3.5 and 3.6 are an example of a common Pantone® colour that was found for black and a Pantone® colour it changed to over time from Sample # 5 shown in Table 3.1.

Figure 3.5. Initial Pantone® colour of black ink circle on sample #5.

Figure 3.6. Resulting Pantone® colour of black ink circle on sample #5 after 141 days in environment.

3.3 Summation

In summary the temperature data collected showed the specimens were subjugated to an average temperature of -4.9°C, below freezing, and that the temperature fluctuated an average of 8°C within the day. With the colour analysis it was seen in almost every sample that the black and blue inks gained cyan saturation. It was also seen that the other colours mostly gained more of their initial pigment deposits.

CHAPTER 4

DISCUSSION

4.1 Canadian Climate and Temperature Data

Decomposition starts to take effect as soon as death occurs, however there are things that can stall the process. Canadian fall and winter climates lend the cold temperatures that can freeze cells and stop or at least slow this process. For the 141 days the samples of this study were out in the environment, they sat in an average of -4.9°C temperature zone as well as being battered by rain, freezing rain, snow, and harsh winds. This environment causes little decomposition of the samples to happen, and therefore not much change to the ink, colour or detail, was seen. Temperature data was collected in this study to help explain the lack of change that was possible to be seen. The samples were still placed out at the time they were to see how the physical environment would potentially change the ink. A previous study (Starkie *et al.* 2011) which looked at re-imaging a tattoo after decomposition and mummification was done in a warm climate where partial mummification of the skin was completed in 17 days. More studies into the effect of the moisture content and insulation properties of snow would effect the tattoo composition in the skin.

4.2 Benefits and Limits of Available Technology

One of the goals of this study was to analyze the results using technology that would be readily available to anyone, or at the very least easily available to an investigative team that would come across tattoos on unknown remains. For this reason, Adobe Photoshop®, a commercially available photograph editing software, was used to analyse the photographs for the CMYK values to give a quantifiable number value to the colours present. There are more combinations of CMYK available than there are classified colours, therefor the values were converted to their nearest corresponding Pantone® colour. Pantone® is a company that has classified colours with their numbering system and is used by graphic designers, interior decorators, and in paint production to regulate colour consistency. This system made it easier to classify if a real difference in the colours were present verses if a non-recognizable difference was present. This also helped to account for the CMYK value being picked from a single pixel in the photograph and matching the CMYK and visual colours to the Pantone® colour to cut out data that was not visually significant. Overall, most ink samples showed a difference in colour from before placement to after retrieval by use of the CMYK to Pantone® system decided upon. Full data showing this is available in Appendix I. Eye-visually, however, most of the ink did not seem to change in colour, whether it was enriching in colour which was shown to happen or darkening of colour which was also show in the CMYK. This indicates a need for a system of analysis that must be decided upon as eye-visually or technological. A technological analysis system would help regulate colour differences and a further analysis into the change of ink could help create a database of change, allowing investigators to understand the tattoo in the original colours.

CHAPTER 5

CONCLUSION

5.1 Summation

The fall and winter environments of Northeastern Ontario do not lead to well established patterns or movements of decomposition, however show the preservative properties of the cold and snow. Eye-visually for the inks, differences could not be seen, however with the use of technology subtle differences were able to be noted. These differences were characteristic to the ink colour and each ink followed the same general pattern of change over the time throughout the environments. Black inks will gain blue tones and lose their sharpness to a greying colour. Red inks will stay mostly consistent but darken slightly in colour. Blue inks will change similarly with purpling almost in colour in some cases, in others simply darkening. Yellow proves to be a difficult colour to categorize in it's change and even initial deposits, but it also follows the general pattern of the initial colour pigments settling and strengthening in concentration, but yellow tended to pick up cyan and magenta tones either from the skin and small decomposition that was occurring or ink transfer of some kind that was not seen at the time of placement.

5.2 Conclusions and Recommendations for Future Studies

The results, or better termed lack of results, of this study are indicative of a needed better approach to researching decomposition of tattoo ink in northern climates. More time is needed to be invested into a project of this nature to truly get results that would contribute to forensic science. These are preliminary results for a specific subset of decay patterns that would be better expanded upon either in time or climate.

The research that has been done on tattoos as identification markers is at a good start, however there are many aspects to tattoos themselves that need to be looked at for this to come together. Looking at the differences in how tattoos appear on remains from the point of view of how old the tattoo would be a good direction to look into. Tattoos can be fresh, as simulated in this experiment, healed, aged, removed, and covered-up. Looking into something that can allow investigators or pathologists to identify the general image and features of tattoos at any stage should be one of the next steps taken. This is where looking more into alternative light sources, such as ultraviolet light and infrared light, as well as standardizing wavelengths to use for this specific purpose would be beneficial. In the circumstance of analyzing the ink colour, even composition, visual technology programs should be found or made to better analyze colour and compare to original colour to compensate for discolouration of the skin from varying factors. As with any good decomposition study, this experiment should be continued in differing climates and environment to best understand how the decomposition and pertaining environmental factors affect the look of the ink. Another avenue of potential interest is to look at the actual chemical composition of the inks and see how they age throughout life and decomposition to potentially be able to identify brands of ink used. The climate of Northeastern Ontario, Canada is vastly different from other environments around the world, and this study would flourish best under different environmental climates.

APPENDIX I

RAW DATA

Temperature Data by Month

Oct-16		
Day	High (°C)	Low (°C)
25	2	-3
26	1	-7
27	1	-3
28	6	-6
29	11	3
30	6	1
31	4	-1

Nov-16		
Day	High (°C)	Low (°C)
1	11	3
2	10	3
3	8	1
4	7	-4
5	13	0
6	13	1
7	17	3
8	10	2
9	5	0
10	14	2
11	5	-2
12	8	-6
13	10	3
14	9	3
15	9	3
16	7	1
17	10	-2
18	15	4
19	13	-5
20	-5	-8
21	-4	-8
22	-3	-7
23	-4	-8
24	-1	-4
25	0	-2
26	-1	-4
27	1	-6
28	2	-2
29	10	0
30	6	2

Dec-16		
Day	High (°C)	Low (°C)
1	4	1
2	1	-2
3	-1	-5
4	-4	-6
5	0	-5
6	-1	-7
7	0	-5
8	-4	-11
9	-9	-12
10	-10	-16
11	-8	-14
12	-6	-8
13	-3	-15
14	-10	-19
15	-17	-25
16	-10	-22
17	-7	-15
18	-15	-24
19	-6	-25
20	0	-6
21	1	-3
22	0	-2
23	1	-2
24	2	-6
25	-6	-13
26	5	-11
27	1	-12
28	-6	-13
29	0	-7
30	-7	-16
31	-9	-15

Jan-17		
Day	High (°C)	Low (°C)
1	1	-15
2	-2	-5
3	-3	-5
4	-3	-18
5	-12	-21
6	-13	-24
7	-13	-23
8	-15	-23
9	-6	-18
10	3	-10
11	3	-5
12	-3	-14
13	-11	-22
14	-5	-22
15	-5	-16
16	0	-7
17	-1	-7
18	0	-3
19	0	-1
20	0	-1
21	1	-1
22	3	1
23	1	-1
24	-1	-2
25	1	-3
26	-1	-5
27	-3	-6
28	-3	-12
29	-12	-17
30	-13	-20
31	-6	-15

Feb-17		
Day	High (°C)	Low (°C)
1	-5	-17
2	-10	-18
3	-8	-17
4	-5	-13
5	-3	-14
6	-9	-15
7	-9	-16
8	-10	-20
9	-10	-27
10	-8	-20
11	-5	-8
12	-4	-9
13	-4	-10
14	1	-9
15	-1	-15
16	-7	-18
17	-2	-15
18	7	-7
19	5	-4
20	1	-10
21	3	-2
22	4	1
23	3	-1
24	-1	-5
25	2	-11
26	-2	-12
27	-2	-10
28	2	-6

Mar-17		
Day	High (°C)	Low (°C)
1	1	-16
2	-10	-21
3	-12	-23
4	-14	-26
5	-5	-21
6	1	-7
7	7	0
8	2	-8
9	-2	-12
10	-11	-20
11	-15	-23
12	-11	-23
13	-11	-21
14	-8	-20

CMYK and Pantone® Data

Sample # & Condition	Ink		C	M	Y	K	Closest Pantone®
1 - Buried	Black	Before	0	2	7	84	Black 7
		After	28	4	0	82	432
	Red	Before	0	63	67	40	4705
		After	0	35	32	51	4715
	Blue	Before	49	34	0	62	7463
		After	77	43	0	53	7463
	Yellow	Before	0	29	86	27	125
		After	8	0	29	38	5783
2 - Buried	Black	Before	0	0	7	73	7540
		After	35	13	0	67	7546
	Red	Before	0	66	70	27	7524
		After	0	53	45	51	4985
	Blue	Before	47	28	0	49	7448
		After	76	55	0	59	540
	Yellow	Before	0	37	84	19	722
		After	1	0	71	49	5835
5 - Surface	Black	Before	0	12	14	83	Black 7
		After	21	6	0	82	432
	Red	Before	0	70	70	31	4705
		After	0	73	70	52	4705
	Blue	Before	51	39	0	65	7448
		After	81	65	0	69	5255
	Yellow	Before	0	49	96	25	7511
		After	0	6	70	52	5835

6 - Surface	Black	Before	10	13	0	81	425
		After	16	0	6	74	432
	Red	Before	0	63	69	42	4705
		After	0	77	77	57	697
	Blue	Before	50	39	0	69	7448
		After	73	65	0	71	5255
	Yellow	Before	0	36	94	17	723
		After	0	8	78	45	4505
7 - Surface	Black	Before	0	0	4	82	425
		After	33	12	0	91	433
	Red	Before	0	56	57	26	7524
		After	0	64	65	65	4705
	Blue	Before	58	37	0	61	2965
		After	73	61	0	72	5255
	Yellow	Before	0	32	82	30	730
		After	7	0	75	52	4505
8 - Surface	Black	Before	0	0	0	75	425
		After	39	6	0	88	7547
	Red	Before	0	73	75	29	1675
		After	0	75	73	48	4705
	Blue	Before	35	21	0	64	7546
		After	73	57	0	67	539
	Yellow	Before	0	33	84	20	7407
		After	7	0	80	36	618
9 - Surface	Black	Before	0	10	18	80	Black 7
		After	35	12	0	84	7547
	Red	Before	0	69	73	42	4705
		After	0	63	64	60	4705
	Blue	Before	29	25	0	70	7546
		After	74	51	0	69	7448
	Yellow	Before	0	40	80	16	722
		After	1	0	66	36	5835
10 - Surface	Black	Before	0	4	5	78	425
		After	35	15	0	90	7547
	Red	Before	0	65	70	31	4705
		After	0	49	46	67	7518
	Blue	Before	49	32	0	49	5405
		After	73	61	0	68	5255
	Yellow	Before	0	33	86	15	7407
		After	8	0	69	64	5835

References:

Bryson, D., Wright, J., & Barker, K., (2013). The identification of tattoo designs under cover-up tattoos using digital infrared photography. Journal of Visual Communications in Medicine, 36(3-4), 104-110.

Byard, R. W., (2013) Tattoos: forensic considerations. Forensic Science, Medicine, and Pathology, 9(4), 534-542.

Canada, Environment. (n.d.). Historical Data. Retrieved from http://climate.weather.gc.ca/historical_data/search_historic_data_e.html

Clarkson, H., & Birch, W., (2013). Tattoos and Human Identification: Investigation into the Use of X-Ray and Infrared Radiation in the Visualization of Tattoos. Journal of Forensic Sciences, 58(5), 1264-1272.

Haglund, W. D., & Sperry, K., (1993). The Use of Hydrogen Peroxide to Visualize Tattoos Obscured by Decomposition and Mummification. Journal of Forensic Sciences, 38(1), 147-150.

Oliver, W. R., & Leone, L., (2012). Digital UV/IR Photography for tattoo Evaluation in Mummified Remains. Journal of Forensic Sciences, 57(4), 1134-1136.

Starkie, A., Birch, W., Fellini, R., & Thompson, T. J., (2011). Investigation into the Merits of Infrared Imaging in the Investigation of Tattoos Postmortem. Journal of Forensic Sciences, 56(6), 1569-1573.